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Case report

Airway fire during tracheostomy

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ABSTRACT

Introduction: Twenty-five cases of airway fire during tracheostomy have been reported in the literature. The authors describe a case observed in their centre 3 years ago, discuss the causes and preventive management and propose guidelines for prevention of this complication.
Case report: A 66-year-old woman was intubated and ventilated with 100% oxygen during general anaesthesia for tracheostomy. On opening the trachea by monopolar diathermy, the oxygen present in the endotracheal tube caught fire, inducing combustion of the tube spreading to the lower airways. This airway fire was responsible for severe acute respiratory failure and the formation of multiple laryngotracheal stenoses.
Discussion: Combustion of the endotracheal tube due to ignition of anaesthetic gases induced by the heat generated by diathermy is responsible for airway fire. These various phenomena are discussed. Prevention is based on safety measures and coordination of surgical and anaesthetic teams.

1. Introduction

About 600 cases of operating room fires are reported each year in the USA [1]. Only 25 cases of airway fire during surgical tracheostomy have been reported, sometimes responsible for severe morbidity and mortality [1]. These events have led some authors to propose prevention and management guidelines. However, no case of airway fire during tracheostomy has been reported in the French language medical literature. We report a case observed in our centre with a follow-up of more than 3 years. In the light of this case and a review of the literature, we discuss the causes, management and prevention of airway fire.

2. Case report

A 66-year-old woman with no comorbidity was scheduled to undergo partial maxillectomy for a cystic adenoid carcinoma of the pterygomaxillary region, starting with tracheostomy. She was intubated with a Covidien Mallinckrodt™ No. 6 cuffed orotracheal tube inflated with room air. The tracheostomy incision was performed between the 4th and 5th tracheal cartilages using monopolar diathermy in cutting mode with an intensity adjusted to 30. The patient was ventilated with 100% oxygen to prevent desaturation. Immediately after the incision, a 15 cm flame burst from the tracheostomy orifice for 2 seconds. Ventilation was stopped immediately and normal saline was used to extinguish the flame. Black smoke was then observed, corresponding to combustion of the endotracheal tube. The burnt endotracheal tube was removed (Fig. 1) and was replaced by a Shiley cuffed tracheostomy cannula. Examination revealed burns of the infrahyoid muscles and a very limited skin burn. Video tracheoscopy revealed circular soot deposits below the tracheostomy orifice descending as far as the carina with burns of the bronchial bifurcations. Multiple sodium bicarbonate irrigations were performed and antibiotic therapy with amoxicillin-clavulanic acid in combination with corticosteroid therapy was initiated.

Regular bronchial laser sessions were performed for 2 months in order to section adhesions resulting from the disorganized healing. Three months after the event, the patient developed dyspnoea at rest due to multiple cicatricial stenoses, requiring the placement of a bifurcated tracheobronchial stent. The patient was operated for her maxillary tumour 5 months later, followed by adjuvant radiotherapy to the tumour bed at a dose of 64 Gy. The tracheostomy cannula was replaced at 6 months by a Montgomery T-tube. The patient was reviewed by monthly bronchoscopy with bronchial aspirates. At 11 months, the bifurcated stent was replaced by a self-expanding Silmet stent covering a 50% stenosis of the left main bronchus. Long-term aerosol and oral corticosteroid therapy (1 mg/kg/day) was administered together with sulphamethoxazole antibiotic prophylaxis. The patient experienced moderate breathlessness on exertion, thick sputum that was difficult to expectorate, and an episode of bronchial superinfection that required prolonged two-agent antibiotic therapy from the 22nd month to the

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Table 1
Literature references and details of airway fires during tracheostomy.

Authors	Mechanism	Monopolar mode	Oxygen source	O_2 concentration
Bowdle et al. (1987)	Thyroid isthmectomy	Unknown	Percutaneous transtracheal jet ventilation	100%
Le Clair et al. (1990)	Tracheal vessel haemostasis	Unknown	Endotracheal tube	100%
Bailey et al. (1990)	Unknown	Unknown	Endotracheal tube	100%
Mandych et al. (1990)	Subcutaneous haemostasis	coagulation	Masque facial	100%
Aly et al. (1991)	Tracheal incision	Unknown	Endotracheal tube	Unknown
Lew et al. (1991)	Tracheal incision	Cutting	Endotracheal tube	100%
Marsh et al. (1992)	Tracheal incision	Coagulation	Endotracheal tube	100%
Wilson et al. (1994)	Tracheal incision	Cutting	Endotracheal tube	100%
Michels et al. (1994)	Tracheal incision	Unknown	Endotracheal tube	100%
Lim et al. (1997)	Tracheal vessel haemostasis	Unknown	Endotracheal tube	100%
Chee et al. (1998)	Unknown	Coagulation	Endotracheal tube	100%
Thompson et al. (1998)	Tracheal vessel haemostasis	Coagulation	Bronchoscope	50%
Thompson et al. (1998)	Tracheal vessel haemostasis	Coagulation	Endotracheal tube	Unknown
Thompson et al. (1998)	Tracheal vessel haemostasis	Unknown	Endotracheal tube	100%
Baur et al. (1999)	Tracheal incision	Unknown	Endotracheal tube	100%
Rogers ML et al. (2001)	Tracheal vessel haemostasis	Coagulation	Endotracheal tube	100%
Rogers SA et al. (2001)	Tracheal incision	Coagulation	Endotracheal tube	100%
Awan et al. (2002)	Tracheal incision	Unknown	Endotracheal tube	100%
Wu et al. (2002)	Tracheal incision	Unknown	Endotracheal tube	100%
Chen et al. (2005)	Tracheal vessel haemostasis	Coagulation	Endotracheal tube	100%
Lin et al. (2005)	Tracheal vessel haemostasis	Unknown	Endotracheal tube	50%
Tykocinski et al. (2006)	Tracheal incision	Unknown	Endotracheal tube	100%
Niskanen et al. (2007)	Tracheal incision	Unknown	Endotracheal tube	100%
Shin et al. (2012)	Tracheal vessel haemostasis	Coagulation	Endotracheal tube	100%
Lee et al. (2012)	Tracheal vessel haemostasis	Bipolar	Endotracheal tube	100%

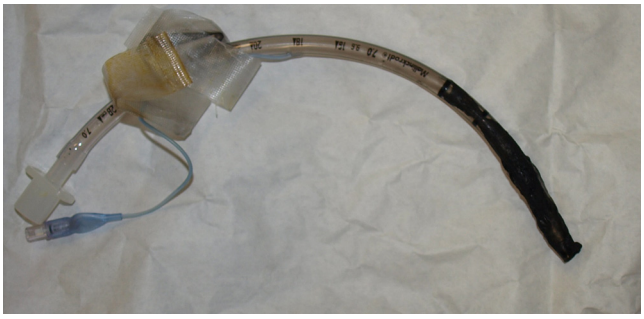

Fig. 1. Burnt lower extremity of the endotracheal tube.

24th month. At 26 months, removal of the left main bronchus stent provided significant improvement with resolution of chronic suppuration and reduction of sputum. At 36 months, the tracheobronchial tract remained stable and the Montgomery T-tube was removed at 39 months.

3. Discussion

Combustion of the endotracheal tube due to ignition of oxygen caused by the heat released by bipolar diathermy in one case and unipolar diathermy in all other cases (Table 1) was responsible for all published cases of airway fire [2,3]. Three elements are necessary to induce fire: fuel, a source of oxygen, and a trigger, i.e. a source of heat or energy.

Standard endotracheal tubes are made of PVC, a material that can burn as soon as the oxygen fraction exceeds 0.25. In 1992 and 1993, Sosis et al. published comparative flammability tests of endotracheal tubes subjected to CO_2 laser in pure oxygen and then tests applied to the monopolar diathermy [4,5]. Endotracheal tubes designed for laser surgery were flammable under test conditions reproducing the local conditions of tracheostomy using monopolar diathermy. Consequently, no endotracheal tube currently ensures absolute prevention of airway fire.

Oxygen is flammable from a concentration of 25% (flammability index: 0.263). However, ventilating the patient with room air during tracheostomy can be associated with a risk of hypoxia. Anaesthetists also usually ventilate the patient with 100% oxygen immediately prior to tracheostomy [6,7]]. Bailey et al. attributed ventilatory oxygen fire to puncture of the endotracheal tube cuff during tracheostomy, responsible for oxygen leak [8]. However, airway fire has been reproduced experimentally by conduction of the heat generated by monopolar diathermy through the endotracheal tube to anaesthetic gases, in the absence of a gas leak [9]. No currently available method of ventilation is therefore able to prevent airway fire.

Monopolar diathermy delivers an energy source generating a temperature peak of 910 °C [10]. Monopolar diathermy has been incriminated when using the cutting mode during tracheostomy or the coagulation mode during secondary haemostasis. Manufacturers do not recommend the use of diathermy in the presence of flammable anaesthetic gases, explosive agents, or endogenous gases and most authors recommend the use of bipolar rather than monopolar diathermy for tracheostomy [2,3,6,8,9].

4. Conclusion

The improved management of airway fire during tracheostomy is based on prevention. We have therefore adopted the following safety measures and recommend them as the minimum prevention measures: reinforce coordination and communication between the anaesthetic and surgical teams; use bipolar diathermy for haemostasis; ensure haemostasis before opening the trachea; do not use diathermy but a cold scalpel for tracheostomy; use the lowest possible FIO_2 to ventilate the patient during tracheostomy; systematically use suction during tracheostomy to eliminate any oxygen and inflammable debris.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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